

Himalayan cryosphere*

The glaciers and seasonal snow melt feed numerous Indian rivers originating from the Himalaya and support millions of people. However, snow and glaciers are sensitive to climate change and the ongoing climate change will potentially affect water availability for millions of people living in North India. Therefore, comprehensive understanding of factors and processes affecting the Himalayan cryosphere is necessary. Hence, a need was felt for an integrated programme to study various aspects of the Himalayan cryosphere. These are glacier retreat, glacier mass budget, glacier volume, snow water equivalent, snow albedo, river run-off, glacier lake, snow avalanches and climatic parameters. This will require multi-disciplinary skills and such resources are distributed at various Indian institutions. Therefore, to bring together scientists with various expertise on one platform, a meeting was recently held to explore the possibility of launching a National Network Programme on Himalayan cryosphere as part of the National Mission for Sustaining the Himalayan Ecosystem (NMSHE) implemented by the Climate Change Programme of Department of Science and Technology (DST), New Delhi. Twenty-five experts from 23 institutions across India participated in the meeting.

The meeting started with introductory remarks by Akhilesh Gupta (DST) who explained the need for a nationally coordinated programme to study the Himalayan cryosphere. He explained that most of the research carried out in India on the Himalayan cryosphere is passion-driven, and hence, information generated in such projects is glacier-specific and local in nature. Therefore, such projects, due to

lack of larger spatial domain and common theme, are not useful for policy makers. In addition, information generated from such projects is distributed in various spatial domains, making it difficult to use for societal benefit. Therefore, he suggested to identify key scientific questions, which can be used by policy makers and also for providing smart solutions. The next talk by Nisha Mendiratta (DST) gave details of the Climate Change Programme implemented by DST and a new programme on 'Human and Institutional Capacity Building (HICAB)' for the Indian Himalayan Region being initiated by DST. She elaborated on the approach to identify potential investigators and themes for the programme and the expectations from the meeting.

Anil Kulkarni (Indian Institute of Science, Bengaluru) made a presentation on the key scientific questions, which can be addressed in the National Network Programme on Himalayan Cryosphere. These are:

- (1) How much is the snow and glacier stored water in the Himalaya?
- (2) What is the current rate of glacier mass loss and how will this change in the future?
- (3) What is the contribution of snow and glacier melt to the total river discharge and how will it change in the future?
- (4) What will be the new challenges faced by society and how can they be mitigated.

Kulkarni also discussed the latest development in the field of glaciology, where field observations, satellite remote sensing and models can be used to address these questions. For example, he explained how to use the field observations from ground penetrating radar, satellite observations like slope and velocity and laminar flow model to estimate glacier stored water. It was suggested that

the current scientific development in the field of glaciology along with the modern observational techniques provide us opportunities to address the aforementioned scientific questions, if different institutions work together.

Subsequently, 16 presentations were made by potential investigators on measurement of various glacier parameters like glacier retreat, glacier volume and glacial mass budget using field and model-based techniques. It also included topics such as quantifying contribution of glacier and snow melt water to river discharge, modelling spatial distribution of snow water volume, mapping of glacier lakes, high-resolution climate models, societal impact of cryospheric changes and glacier lake disaster assessment. These presentations demonstrated the scientific capacity of Indian researchers and institutions. The participants realized that upscaling of existing research, sharing expertise, data and information are needed to meet scientific goals. Therefore, the meeting resolved to undertake a nationally integrated programme on the Himalayan cryosphere to address the following themes:

- (1) State of the Himalayan cryosphere.
- (2) Current and future glacier mass loss.
- (3) Water availability due to the changes in snow/glaciers.
- (4) Societal impact of cryospheric changes.

The meeting concluded with finalizing the timelines for steps forward to establish the National Network Programme on Himalayan Cryosphere.

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